Who Will Pay for the Energy Transition?: Affordability, Efficiency, and Retail Energy Price Regulation

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The most promising path to deep decarbonization runs through the electricity sector. The goal is to reduce the carbon-intensity of the electricity sector and accelerate the electrification of other carbon-intensive sectors (e.g., transportation, buildings, and some industrial applications). This will require major investments in a power system that needs to become not only more environmentally sustainable, but also more reliable and resilient to increasingly frequent extreme weather events.

How we pay for these investments will determine, to a significant extent, how much this energy transition will cost and who bears that cost. Under a business-as-usual scenario, these costs will be passed through to electricity consumers in the form of higher retail rates. But high electricity prices have troubling implications for both efficiency and equity. Increasing retail electricity prices may undermine electrification by lowering the private returns to fuel switching and electric vehicle adoption. And high electricity prices impose a disproportionate burden on low-income households in an increasingly unequal economy.

In this context, we pursue three research questions. First, what are the distributional implications of using retail electricity prices as a vehicle to pay for climate resilience and the clean energy transition, given existing rate structures? Second, how could alternative rate structures and/or financing strategies support a more equitable energy transition? And finally, what are the efficiency implications of alternative rate structures given the central role of electrification in the clean energy transition?

We will answer these questions using detailed microdata on residential electricity consumption from California. Specifically, we have obtained residential monthly billing data from the state's three large investor-owned utilities, covering about 11 million households over five years. We are pursuing data from two other large utilities that would strengthen the analysis. The challenges facing California today make it a bellwether for other regions. California is already experiencing rising climate adaptation costs due to wilsoladfires, it is ahead of most states in rooftop solar penetration, which plays an important role as explained below, and it has already put a spotlight on equity.

Question 1: What are the distributional implications of high retail electricity prices?

We begin by extending the classic theory of utility rate regulation to accommodate some important features of California's utility rate structures and energy policies. California's IOUs have among the highest residential electricity rates in the country (approximately double neighboring states) due to many fixed system and policy costs that are collected through

electricity bills, including the large rate discounts for low-income customers, wildfire mitigation costs, liabilities from past wildfires caused by grid infrastructure, energy efficiency programs, rooftop solar subsidies, and investments in R&D for new technologies. In addition, California IOUs collect virtually all revenue from residential customers through volumetric charges. As a result, we find that California residential customers pay incremental prices that are 2-3 times higher than social marginal cost.

High retail electricity prices create significant tensions when combined with two state policies designed to reduce greenhouse gas emissions. First, electricity consumers now have an outside option, rooftop solar, which is compensated at retail rates. Rooftop solar adoption will exacerbate the regressivity of standard retail electricity pricing regimes if, as is the case in California, higher income households are most likely to adopt solar as retail prices rise. Second, the central role of electrification in the clean energy transition changes the social welfare calculus with respect to inefficiencies associated with linear retail electricity pricing. High electricity prices can increase GHG emissions via a fuel substitution effect. These tensions in California are likely indicative of the challenges other states will face as they try to decarbonize their electric grid and as they try to phase out natural gas combustion in homes, both goals that many states have adopted with varying time frames.

To assess the distributional implications of the electricity prices that California households are currently paying, we assemble a large dataset of household-level electricity consumption, electricity expenditures, and solar PV adoption in California. We analyze data from 11 million California households over 2016-2020. Using a variety of market and regulatory data sources, we estimate that the average retail rates paid by California households are 2-3 times higher than the social marginal cost of electricity consumption. In other words, California is taxing electricity consumption at a rate that exceeds 100% to pay for needed investments in climate change adaptation and mitigation, other infrastructure, and social programs.

Using the electricity consumption and expenditures we observe at the household level, together with estimates of social marginal cost, we infer the electricity tax burden for each household. We then develop a new method of estimating household income by combining billing and survey data, which allows us to assess the relationship between the electricity tax incidence and income. Our method reveals significant income variation that is obscured when analysts assign average income from a geographic unit, such as the Census block group, to individual households, as is common practice. We find that the correlation between net electricity consumption from the grid and income is only weakly positive, so this electricity tax is much more regressive than other forms of taxation that could be used to raise needed revenues (e.g. sales tax, gasoline tax, or income tax).

Question 2: Can alternative rates improve equity and efficiency?

Next, we compare the distributional impacts under the current rate structure vis a vis alternative revenue sources. Whereas the analysis in the previous section held household consumption at observed levels, counterfactual analysis should account for household-level responses to

electricity price changes. To this end, we are developing a model that jointly describes the household's discrete rooftop solar adoption choice and continuous choice of grid electricity demand. We plan to estimate the model using detailed micro-data on household-level electricity prices, electricity consumption, and solar PV adoption. An important source of identification comes from the variation in electricity prices faced by households living on either side of utility service territory borders.

This empirically estimated model will be used to simulate rooftop PV adoption and household-level electricity demand under alternative electricity pricing regimes that set retail rates equal to social marginal cost and satisfy revenue recovery requirements using other state revenue sources or an income-based fixed monthly charge. An analysis of how costs are reallocated in equilibrium across alternative regimes allows us to evaluate both the efficiency and distributional implications. For each alternative, we will calculate a Suits index to provide a consistent, comparable metric of progressivity. We will leverage our detailed billing data to provide plots that show the distribution of winners and losers under each scenario, exploring how costs are allocated across households that differ by income, region, race, and other characteristics. This approach supports an evaluation of not just vertical equity, but also horizontal equity and transitional equity.

Question 3: What are the efficiency implications of alternative rate structures given the central role of electrification in the clean energy transition?

The final phase of the project will further explore the efficiency properties of alternative rate structures. Whereas our econometric model of solar PV adoption and grid electricity consumption capture some important choice dimensions, it does not explicitly capture impacts on fuel substitution choices. To investigate implications for electrification, we will combine CBG-level centers and survey data on household demographics, housing stock, and transportation patterns with specifications of electric versus fossil appliances and vehicles to study the propensity to switch between fuel sources for energy services. This will provide a locationally granular analysis of likely fuel switching in response to changing prices of different energy sources, and the implied distortion from energy prices that deviate from social marginal cost. As this is somewhat less relevant to this conference call, we do not emphasize this here.

Potential Contributions

This research will contribute to the literature on utility price regulation (e.g., Levinson and Silva, *AEJEP*, forthcoming; Borenstein and Bushnell, *AEJEP*, forthcoming; Davis and Hausman, 2022) by extending the standard analysis of energy price regulation to account for first order interactions between utility regulation and climate change policies and priorities. In our view, these interactions present under-appreciated challenges of the clean energy transition. In addition to elucidating the challenges, the research proposes some potential alternatives (i.e. income-based fixed charges).

This empirical exercise will also shed light on the current debate over the distributional implications of net metering policies in California, and the extent to which solar PV adoption shifts cost recovery burden onto lower income households.

References

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Disclosures

Severin Borenstein is a member of the Board of Governors of the California Independent System Operator. The authors have no other ties to the energy industry and no other conflicts of interest.